REMARKS

Upon entry of the amendments, claims 8-20 will be pending in the application. Claims 1-7 have been canceled. The specification has been amended to further recite "by means of an error signal" on page 5 (support found in original claim 2) and to include four paragraphs explaining the flow chart shown in figure 4. No new matter has been introduced as the original figure 4 and original disclosure explaining the claimed method establish either explicit or non ambiguous inherent support for the changes. Applicant is also amending figure 4 to be consistent with the original disclosure appearing on page 5 of the application. The previous figure 4 had a translation error pertaining to the "minimum expected time at a certain position", which has been amended to match the disclosure appearing in the application.

Claim Rejections – 35 U.S.C. § 102

Claims 1 and 4-7 are rejected under 35 U.S.C. §102(b) as being anticipated by Yajima (US 4,465,959). Applicant notes that the Examiner clarified during a telephone conversation that the rejection pertains to claims 1-7. These claims have been canceled and therefore the rejection is believed to be moot.

Claim Rejections – 35 U.S.C. § 112

Claims 4 and 7 are rejected because of the phrase "may be". These claims have been canceled from the application and the rejection is believed to be moot.

New Claims

Applicant has added new claims 8-20 to the application. These claims are based on the

original claims and provide further details regarding the claimed invention.

Applicant respectfully submits that none of the prior art references (US 4,465,959, (the Yajima patent cited by the Examiner), JP09261991 and US 4,532,461 (disclosed by Applicant in the Information Disclosure Statement)) disclose a method, a control system, nor a motor that simultaneously monitors the occurrence of an incorrect positioning of the rotor of the motor with respect to the poles and further evaluates if a correct position change has occurred.

New claim 8 also recites a method wherein the system continuously reads the position detector and only reacts if a position change is detected or if a minimum expected time has passed.

Claims 11 and 15 recite a control system/motor that reads the position detectors until a minimum expected time has passed and subsequently starts to count for a maximum period of time when a position change is expected to occur.

Since none of the prior art references (Yajima, JP09261991, and US 4,532,461) inherently or explicitly disclose these features, Applicant asserts that the claimed invention is not anticipated by the cited prior art.

Applicant also asserts that the claimed invention would not be considered obvious in view of the cited prior art. While JP09261991 (see the accompanying computer generated translation to supplement the abstract for this previously disclosed reference) teaches that the time between the passage of a rotor at a certain pole of the motor and the passage by the following pole shall be monitored by means of the time spent between these events, it fails to predict that an incorrect phase of the motor would be selected by the controlling circuit.

Moreover under the techniques of US 4,532,461 (another reference that was previously disclosed) one will only measure if a correct phase has been energized and thus there is neglected

the fact that the rotor might have variations in its speed and that it might rotate faster or slower than predicted.

Further, the claimed invention sets forth reading the position detector and only reacting if a position change is detected or if a minimum expected time has passed. This provides for the ability to prevent an incorrect detection of position from taking place.

Such an incorrect detection could occur, for example, if the system is submitted to an unforeseen surge current or the like. In that event, even having predicted that the rotor should be between two different poles of the motor during a certain period of time, the system would be susceptible to misinterpret the occurrence of the surge, for example as a detection of a position change of the rotor. Applicant notes that this could occur in a system according to the teachings of JP09261991.

In contrast to that, since according to the recited invention one would ignore for a certain period of time, and more precisely for the minimum expected time, any unforeseen signal, and would only start to measure effectively if the rotor has advanced from one pole to the next one after that period. This would than be done within a range of time starting from the minimum expected time and the maximum expected time.

Another aspect of the invention as outlined in , for example, claim 8 refers to the fact that the system will monitor if a complete turn of the rotor has been reached to calculate a corrected value of the maximum and minimum expected times for a certain current speed. This will allow the system to be more flexible in its application, when compared to systems that only consider the changes that occur between two poles. One example in that sense would be if the motor is applied to control a compressor for refrigeration systems. In these applications, since the compressor will demand a different force from the motor during its charging and discharging

cycles, half of the turn of the rotor will be submitted to a certain force, while the other half of the turn of the rotor will be submitted to another force that might be higher or smaller. The result of that the rotor will not have an equal speed around one both parts of the turn and thus resulting in an inaccurate control of the rotor.

The result of the above features is that the system as recited in the amended claims will be more flexible and more reliable when compared to the systems disclosed in Yajima, JP09261992 and US 4,532,461.

Accordingly, Applicant considers that the teachings of Yajima, JP09261991, and US 4,532,461, whether taken alone or considered together, fail to teach one skilled in the art the claimed invention.

New claim 18 also includes features as discussed above and thus is respectfully submitted to be in condition for allowance.

The subject matter of dependent claims should be considered patentable, since the independent claims are not anticipated or obvious in view of the cited prior art.

CONCLUSION

Applicant earnestly awaits allowance of the application. If any additional fees are due in connection with the filing of this response, such as fees under 37 C.F.R. §§ 1.16 or 1.17, please charge the fees to Deposit Account No. 02-4300. Any overpayment can be credited to Deposit Account No. 02-4300.

Respectfully submitted,

SMITH, GAMBRELL & RUSSELL, LLP

Dated: December 5, 2003 By:

Brandon Boss, Reg. No. 46,567*
1850 M Street, N.W., Suite 800
Washington, D.C. 20036
Telephone: (202) 659-2811
Facsimile: (202) 263-4392

* Practice is limited to matters and proceeding before federal courts and agencies.

JP09-261991

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention changes energization of armature-winding current on the point which counter torque does not generate even if it starts the roll control technology of a sensor loess direct-current brushless motor (it is described as a brushless motor below) used for the compressor of an air conditioner etc. and there is no position detection of the rotator of a brushless motor in detail especially, and relates to the control method of the brushless motor which makes a suitable roll control possible -- it is a thing

[0002]

[Description of the Prior Art] There is a method of using the voltage by which induction is carried out to the armature winding of a brushless motor, without using a hall device as a means to detect the position of a rotator in the roll control of this brushless motor. When detecting the position of a rotator using this induced voltage and changing energization of the armature-winding current of a brushless motor based on this position detection, the control unit shown in drawing 6 is needed.

[0003] In drawing 6 , by the voltage-doubler-rectifier smoothing circuit 2, it smooths, and this control unit switches AC power supply (commercial 100V) 1 by the voltage doubler rectifier and the inverter circuit 3 which carried out bridge connection of two or more switching elements (transistor) U, V, W, X, Y, and Z for this voltage doubler rectifier and DC power supply Vdc by which smoothing was carried out, and impresses it to the armature winding of the brushless motor 4 of a three phase. In addition, the voltage-doubler-rectifier smoothing circuit 2 already consists of a well-known rectifier circuit, a capacitor circuit, and a capacitor for smooth.

[0004] The terminal voltage (for example, the voltage; induced voltage from which a phase differs 120 degrees is included) R, S, and T of a brushless motor 4 is inputted into the position detecting element 5, and it phase-****** 90 degrees, and this position detecting element 5 smooths the voltage waveform of terminal voltage R, S, and T, and outputs the position detecting signals A, B, and C to a control circuit (microcomputer) 6 as compared with the neutral point potential Vn. Therefore, the position detecting element 5 is equipped with 5d of comparator circuits which compare differential circuit 5a and integrating-circuit 5b, and resistance circuit 5c for combining the voltage of phase lag 90 degrees and obtaining the neutral point potential Vn with the voltage and the neutral point potential Vn of the aforementioned 90-degree phase lag.

[0005] Synchronized operation is carried out, and starting and after performing this synchronized operation predetermined time, energization of each armature winding is changed for a brushless motor 4 based on the position detecting signals A, B, and C from the position detecting element 5. Therefore, a control circuit 6 turns on the switching elements (transistor) U, V, W, X, Y, and Z of an inverter circuit 3, and outputs the driving signal which carries out an OFF drive, and the chopping signal which carries out a chopping drive to the drive circuit 7.

[0006] In addition, as shown in drawing 6 , when using the aforementioned control unit for control of the compressor of an air conditioner, it is good to form the reactor 8 for power factor improvement between AC power supply 1 and the voltage-doubler-rectifier smoothing circuit 2.

[0007] If operation of the control unit of the aforementioned composition is explained with reference to the timing diagram view of drawing 7 The position detecting element 5 at the time of position detection operation makes phase lag terminal voltage R, S, and T of each armature winding shown in this drawing (a) or (c) 90 degrees. The voltage (shown in this drawing (d) or (f)) and the neutral point potential Vn of this phase lag are compared, and the position detecting signals (shown in this drawing (g) or (i)) A, B, and C which change on the intersection are outputted.

[0008] A control circuit 6 generates the driving signal (shown in drawing 7 (j) or (o)) which changes the switch-on of each transistors U, V, W, X, Y, and Z of an inverter circuit 3 based on the timing of the position detecting signals A, B, and C.

[0009] Since each transistors U, V, W, X, Y, and Z drive by each driving signal, energization of the armature-winding current of a brushless motor 4 is changed, and rotator 4a rotates so that the rotating magnetic field which this generates in a stator may be followed.

[0010] Moreover, the control circuit 6 is outputting the chopping signal of a predetermined duty ratio (ON, OFF ratio) other than a driving signal to the drive circuit 7, and the drive circuit 7 carries out chopping of the ON portion of the driving signal of the transistors U, V, and W of the upper arm of an inverter circuit 3 (shown in drawing 7 (j) or (l)). In addition, there is also the method of carrying out the chopping drive of the transistors X, Y, and Z of a lower arm.

[0011] Thus, a brushless motor 4 is controllable to a predetermined rotational frequency by changing energization of each armature-winding current of a brushless motor 4 based on the position detecting signals A, B, and C, and carrying out the roll control of this brushless motor 4, and carrying out adjustable [of ON of chopping, and the OFF ratio].

[0012]

[Problem(s) to be Solved by the Invention] By the way, since integrating-circuit 5b was used for **, it detected the position of rotator 4a and has obtained energization change timing by this position detection to the control method of the aforementioned brushless motor, the following troubles produce it in it.

[0013] First, various frequency components are intermingled in the voltage waveform by which induction is carried out to an armature winding, and constant determination to all the frequency of them is not made to it on the property of integrating-circuit (integrating filter) 5b. Therefore, with the frequency which the frequency component which is not needed will be contained in the voltage waveform which let the integrating circuit pass, especially is contained by change of the rotational frequency of a brushless motor 4, an error arises in 90 output delay and an error arises in position detection of result rotator 4a.

[0014] Moreover, from needing integrating-circuit 5b etc., there is nothing as it surely becomes a cost rise, and there is also a fault of a control board being large and taking a space by the increase in parts.

[0015] Furthermore, since the energization change timing which delay is not the optimal, that is, makes efficiency of a brushless motor 4 the maximum the 90 degrees depending on the rotational frequency and loaded condition of a brushless motor 4 although the 90-degree delay acquired through integrating-circuit 5b is always fixed changes with a rotational frequency or loaded condition, energization cannot be changed so that it may always become the greatest efficiency.

[0016] Then, there is the method of detecting the position of rotator 4a and carrying out the roll control of the brushless motor 4, without using

integrating-circuit 5b. In the case of this control method, the voltage waveform and neutral point potential (reference voltage) by which induction is carried out to an armature winding are compared, this comparison result is inputted into the control circuit (microcomputer) of a brushless motor 4, it calculates with this microcomputer, and energization change timing is determined.

[0017] If it explains concretely, the position detecting signal which compared and obtained the terminal voltage wave (induced-voltage wave) and reference voltage (Vdc/2) of an armature winding directly will be inputted into a microcomputer. This microcomputer makes the changing point of the position detecting signal of the beginning after an energization change the point of rotator 4a detecting [position], and changes energization of an armature winding from this point detecting [position] at the time of time [to be equivalent to 30 phase angles (30 electrical angles)] progress.

[0018] Thus, the method which does not use integrating-circuit 5b to obtaining the position detecting signal (energization change timing in 90 degrees) of delay 90 degrees using integrating-circuit 5b (it is possible to change energization from the intersection of an induced voltage and reference voltage to the optimal timing (30 degrees of a predetermined angle) in a digital method.)

[0019] However, in the case of this digital method, the changing point (detection edge) of the position detecting signal of the beginning after an energization change is not acquired by energization change by the noise by the reverse electromotive voltage (spike voltage k) etc. That is, voltage width of face of the spike voltage k may be unable to be large, the position detection point (intersection of an induced voltage and reference voltage) may be unable to be started, and the position detection point may be unable to be obtained.

[0020] Thus, when the spike voltage k is built over position detection PONTO and position detection of rotator 4a becomes impossible, trouble is caused to the roll control of a brushless motor 4, and it is [that the cause of step-out and a halt cannot be continued by position detection operation, and] also with a bird clapper.

[0021] This invention is made in view of the aforementioned technical problem, a halt and step-out can be prevented, without it seeming that trouble is caused to a roll control even if the purpose is the case where position detection of the rotator of a brushless motor cannot be performed, and it is in offering the control method of the brushless motor which enabled it to continue position detection operation.

[0022]

[Means for Solving the Problem] In order to attain the aforementioned purpose, this invention detects the position of the rotator of this brushless motor by the position detecting signal which compared and obtained the induced voltage and reference voltage which are generated in the armature winding of a brushless motor. While being the control method of the brushless motor which changes energization of the armature-winding current of the aforementioned brushless motor on the basis of this position detection and clocking and memorizing the time (ta) of position detection of the aforementioned rotator The time (TA) of a position detection interval is computed by the memorized this position detection time (ta) and the last position detection time (tb). The energization change time (tk) after homotopic detection time (ta) is predicted by the time (TA) of the aforementioned position detection time (ta) and a position detection interval. And the position detection time (taa) after the predicted this energization change time (tk) is predicted. While changing energization of the aforementioned armature-winding current at the energization change time (tk) which carried out [aforementioned] prediction When there is no position detection of the aforementioned rotator by the predetermined-time progress on the basis of this energization change time (tk) that carried out account prediction of energization change back to front, energization is changed in between said place scheduled time. And it is characterized by considering that the position detection time (taa) which carried out [aforementioned] prediction is time with the aforementioned position detection, and memorizing it.

[0023] While the control method of the brushless motor this invention clocks and memorizes the time (ta) of position detection of the aforementioned rotator The time (TA) of a position detection interval is computed by the memorized this position detection time (ta) and the last position detection time (tb). The energization change time (tk) after homotopic detection time (ta) is predicted by the time (TA) of the aforementioned position detection time (ta) and a position detection interval. And the position detection time (taa) after the predicted this energization change time (tk) is predicted. While changing energization of the aforementioned armature-winding current at the energization change time (tk) which carried out [aforementioned] prediction When there is no position detection of the aforementioned rotator by time progress of the predetermined rate of the time (TA) of the aforementioned position detection interval on the basis of this energization change time (tk) that carried out account prediction of energization change back to front, energization is changed in between said place scheduled time. And it is characterized by considering that the position detection time (taa) which carried out [aforementioned] prediction is time without the aforementioned position detection, and memorizing it.

[0024] While the control method of the brushless motor this invention clocks and memorizes the time (ta) of position detection of the aforementioned rotator The time (TA) of a position detection interval is computed by the memorized this position detection time (ta) and the last position detection time (tb). The energization change time (tk) after homotopic detection time (ta) is predicted by the time (TA) of the aforementioned position detection time (ta) and a position detection interval. And the position detection time (taa) after the predicted this energization change time (tk) is predicted. While changing energization of the aforementioned armature-winding current at the energization change time (tk) which carried out [aforementioned] prediction When there will be no position detection of the aforementioned rotator by the time corresponding to the maximum predetermined angle which the torque which serves as a hand of cut and a retrose to this account rotator of energization change back to front does not generate, energization is changed in between said place scheduled time. And it is characterized by considering that the position detection time (taa) which carried out [aforementioned] prediction is time with the aforementioned position detection, and memorizing it.

[0025]

[Embodiments of the Invention] Hereafter, the form of implementation of this invention is explained in detail with reference to drawing 1 or drawing 5 . In addition, among drawing 1 , the same sign is given to the same portion as drawing 6 , and a corresponding portion, and duplication explanation is omitted.

[0026] In drawing 1 , the control unit which applied the control method of this brushless motor compounds the terminal voltage (an induced voltage is included) R, S, and T of the armature winding of a brushless motor 4, obtains neutral point voltage, compares this neutral point voltage and reference voltage by the position detector 10, and outputs them to a control circuit (microcomputer) 11 by making this result into the position detecting signal D. In addition, the position detector 10 consists of a circuit which compares with reference voltage the circuit which compounds terminal voltage R, S, and T, the circuit which generates reference voltage, and the neutral point voltage compounded and obtained, and outputs the position detecting signal D.

[0027] The changing point of a control circuit 11 and the position detecting signal of the beginning after an energization change detects the position of rotator 4a. While clocking and memorizing the time of this position detection, the time of position "*****" is computed by this position detection time and the last position detection time. Energization change timing is computed based on the time and the position detection interval of this position detection (or deemed position detection mentioned later) (this energization change time is predicted).

[0028] Moreover, while predicting this aforementioned energization change time, the position detection time after this energization change is predicted, and when position detection cannot be performed by the predetermined time from the energization change time which carried out aforementioned] prediction, while changing energization compulsorily, it carries out as the time position detection was able to be carried out in the position detection time carried out [aforementioned] prediction.

[0029] In addition, when the aforementioned predetermined time is made into time (time found experientially) for the time corresponding to the

maximum predetermined angle which the torque which considers as the time of the predetermined rate of a front position detection interval, or serves as inverse rotation to rotator 4a by the rotating magnetic field of the stator after an energization change does not generate to come, it is desirable.

[0030] In addition, a control section 11 outputs a driving signal, a chopping signal, and the change signal of chopping to the drive circuit 12, in order to carry out PWM control of the brushless motor 4, as it has the function (other functions required for a roll control) of a control circuit 6 shown in drawing 6 and is shown in drawing 4 (d) or (i).

[0031] Next, if operation of the aforementioned control unit is explained in detail with reference to drawing 2 and the flow chart view of drawing 3 , and drawing 4 and the timing diagram view of drawing 5 , the roll control of a brushless motor 3 shall be contained in position detection operation mode first.

[0032] In this case, as shown in drawing 3 and drawing 4 , the position detector 10 compounds the terminal voltage R, S, and T of a brushless motor 4, compares neutral point voltage (refer to drawing 4 (d)) with reference voltage, and outputs the position detecting signal D which changes on the intersection of this comparison result (refer to drawing 4 (e)).

[0033] Then, a control circuit 11 detects the position of rotator 4a with the changing point (edge) of the position detecting signal of the beginning after an energization change (after the spike voltage k), and changes energization of armature-winding current based on this position detection. Therefore, as shown in drawing 4 (d) or (i), while outputting the driving signal which drives the transistors U, V, W, X, Y, and Z of an inverter circuit 3, the chopping signal and change signal which carry out chopping of the predetermined section of a driving signal according to the directions rotational frequency of a brushless motor 4 are outputted.

[0034] At this time, a control circuit 11 performs the routine shown in drawing 2 and drawing 3 at the time of position detection, and in order that that the next position detection cannot be performed probably may also enable a compulsory energization change supposing a certain thing, an internal tjk flag is cleared (step ST 1).

[0035] Then, while clocking and memorizing the time ta of position detection (step ST 2), the time tb of the last position detection is read (step ST 3), and the difference TA of Time ta and tb (time of a position detection interval) is computed (step ST 4).

[0036] Then, in order to predict the energization change time tk (refer to drawing 4 (d)) after the position detection time ta, the energization change time (this energization change time) tk is computed by adding predetermined rate TAxx (for example, x=1/2) of the time TA of a position detection interval to the position detection time ta, and the position detection time taa (refer to drawing 4 (d)) after this prediction energization change time tk is also predicted (step ST 5). In addition, about the prediction position detection time taa, the position detection interval TA is added and obtained, for example at the position detection time ta.

[0037] Then, in order to change energization at the energization change time tk which carried out [aforementioned] prediction, Time tk is set up as energization change timing (step ST 6).

[0038] Moreover, supposing the ability not to perform position detection after the aforementioned prediction energization change time tk, a predetermined time is added to the energization change time tk, the next energization change time tjk (refer to drawing 4 (d)) is computed further (step ST 7), and processing for performing the routine to which interruption is applied at this time tjk and which is shown in drawing 3 is performed (step ST 8). In addition, as the aforementioned predetermined time, as mentioned above, it considers as time (time found experientially) for the time corresponding to the maximum predetermined angle which the torque which considers as predetermined rate TAxy, of the time TA of a front position detection interval, or serves as inverse rotation to rotator 4a by the rotating magnetic field of the stator after an energization change does not generate to come. Moreover, as y, although 1 is sufficient, for example, it is good to determine that Time tjk will become reconfiguration before by the re run of the routine of drawing 2 .

[0039] Therefore, when there is no position detection, a suitable energization change is possible, and since energization can be changed at the time corresponding to the maximum predetermined angle which the torque used as especially inverse rotation does not generate, the situation which serves as step-out and a halt can be prevented.

[0040] Then, an internal tjk flag is set (step ST 9), and the aforementioned position detection time ta is transposed to tb, and is memorized (step ST 10).

[0041] Therefore, if it reaches at the prediction energization change time tk which the present time set up as shown in drawing 5 (d), energization of armature-winding current will be changed and the intersection (position of rotator 4a) of the induced voltage and reference voltage which are generated in a non-energizing armature winding by this energization change after an appropriate time will be detected.

[0042] Although the processing which reran, was got blocked and mentioned above the routine shown in drawing 2 is repeated when position detection is completed, after energization changing at the aforementioned time tk, the intersection (position detection point of rotator 4a) of an induced voltage and reference voltage may hide in the spike voltage k etc., for example, and position detection may not be able to be performed (refer to the wavy line of drawing 5). If the present time reaches at Time tjk, with this position detection not performed, the routine shown in drawing 3 will be performed.

[0043] First, it judges whether the tjk flag is set (step ST 21). In this case, since the routine shown in drawing 2 is not rerun and a tjk flag is set, it progresses to ST22 from a step ST 21, and energization is changed immediately.

[0044] Then, it is regarded as the position detection time taa (refer to drawing 5 (d)) which predicted the time whose position detection was not completed this time, and the position detection time tb already memorized in the aforementioned step ST 10 is rewritten to tb+TA (predicted position detection time taa; drawing 5 (d) ta+TA) (step ST 23). That is, it is for performing processing (calculation processing of suitable energization change time) suitable at the time of execution of the routine shown in drawing 2 at the time of the position detection next to the predicted position detection.

[0045] And the intersection of the induced voltage and reference voltage which were generated by the energization change of a step ST 22 is detected, the time (refer to position detection time tx; drawing 5 (d)) of this intersection is obtained and memorized (step ST 1), and the routine shown in drawing 2 mentioned above like the following is performed.

[0046] Thus, the energization change after regarding at the position detection time which predicted the point which could perform the suitable energization change even if position detection hid with the spike voltage k etc. and position detection was not completed, and was not able to carry out position detection can be performed.

[0047] Moreover, terminal voltage (an induced voltage is included) was compounded, neutral point voltage was obtained, the comparison result of this neutral point voltage and reference voltage detected the position of a rotator, and energization is changed on the basis of this position detection. By the position detector 10 which adopted this digital method, the trouble of the position detector of the analog method using the integrating circuit etc. can be canceled, and moreover circuitry can also be simplified, as a result a cost fall can be aimed at.

[0048]

[Effect of the Invention] As explained above, even if it is the case where position detection of the rotator of a brushless motor cannot be performed, among the control methods of the brushless motor this invention according to invention of a claim 1 By the position detector which could continue position detection operation and adopted the digital method, without it seeming that an energization change can be performed, a result halt and step-out can be prevented, and trouble is caused to a roll control The trouble of the position detector of the analog method using the integrating circuit etc. can be canceled, and moreover circuitry can also be simplified, as a result it is effective in the ability to aim at a cost

fall.

[0049] Even if there is no position detection according to invention of a claim 2, an energization change can be performed appropriately, and the same effect as a claim 1 is done so.

[0050] The same effect as a claim 1 is done so, without according to invention of a claim 3, being able to perform an energization change appropriately, even if there is no position detection, and moreover the situation of inverse rotation happening.

[Translation done.]